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09/881,684	06/18/2001	Otto Z. Zhou	032566-011	8607

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EXAMINER	
LISH, PETER J	
ART UNIT	PAPER NUMBER
1754	9

DATE MAILED: 10/25/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

AS-9

Office Action Summary	Application No.	Applicant(s)
	09/881,684	ZHOU, OTTO Z.
	Examiner	Art Unit
	Peter J Lish	1754

-- The MAILING DATE of this communicati n appears on th cover sheet with the correspondence address --

Peri d f r Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 10/10/02.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disp sition of Claims

4)☒ Claim(s) 1-64 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-64 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☒ Claim(s) 65-70 are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 6.
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Election/Restrictions

Applicant's election with traverse of the invention designated as corresponding to Group 1 (claims 1-64) in Paper No. 8 is acknowledged. The traversal is on the ground(s) that the searching of 5 more claims does not pose a serious burden to the examiner. This is not found persuasive because the content of claims 65-70 include any and all devices which contain carbon nanotubes and are used for electron emission. The range of these devices demands a significant and distinct search in relation to the process of intercalating nanostructures.

The requirement is still deemed proper and is therefore made FINAL.

Claim Rejections - 35 USC § 112

The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Claims 36-38 are rejected under 35 U.S.C. 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. The composition A_xC where X = 0 to 1 is viewed as both inconsistent with the disclosure and impossible. When X is 0, there is no foreign species within the nanostructure, thus the claim is simply a fullerene or nanotube, contradicting the disclosure. When X is 1, the

applied stoichiometry of 1 foreign atom to 1 carbon atom is impossible. Perhaps C_{60} or C_N where N is at least 60 was meant.

The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Claims 31-33 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The limitation "passivation layers" is indefinite and unclear. It cannot be determined from the claim, as read, whether the tubes are closed by capping, or a layer which sits adjacent to the tube tips meets the 'enclosing' limitation.

Claims 36-38 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The term 'strong' as used in 'strong acid' is subjective and thus unclear.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1-3, 10-11, 20-21, and 26-28 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan et al (USPN 5,457,343) in view of Hiura et al (USPN 5,698,175). Ajayan discloses a process by which a nanometer sized carbon tubule enclosing a foreign material, except for carbon, may be produced. This process includes the steps of producing a nanotubule, opening a top portion of the tubule, introducing a foreign material into the center hollow through this opening, and re-closing the tubule. It does not include the step of purifying the tubules. Hiura et al. teach a similar process by which carbon nanotubes are purified, uncapped (opened), and filled. This purification stage is undertaken to provide high-quality carbon nanotubes, which do not contain nanoparticles and amorphous carbon. These are required in order to achieve the desired properties of the product tubes (column 2, line 64 to column 3, line10). It thus would have been obvious to one of ordinary skill at the time of invention to include the purifying step of Hiura in the process of Ajayan.

Ajayan discloses that the carbon tubules "may comprise a single cylinder of a graphite carbon monoatomic sheet" or alternatively "may comprise a plurality of cylinders of the graphite monoatomic sheets" (column 2, lines 45-59). Thus, the nanostructure may comprise SWNTs or MWNTs.

Regarding claims 10-11, whereas Ajayan does not include a purification step, the purification stage of Hiura involves acid reflux followed by filtration. This can be seen in Example 1, where the nanotubes are refluxed in a mixture of sulfuric acid and nitric acid and then filtered by a glass filter (column 4, lines 49-55). It is also seen in Example 5.

Regarding claims 20-21 and 26, Ajayan teaches that useful foreign materials to be introduced into the nanometer sized carbon tubule include alkali metals such as: lithium, sodium, potassium, rubidium, and cesium (column 3, lines 21-35).

Regarding claims 27-28, Ajayan teaches that the foreign material may be introduced by evaporation on the top of the tubule or alternatively by contacting the top of the tubule with the gaseous compound including the foreign material (column 3, line 60 to column 4, line 3).

Claims 4, 18-19, 35, and 52 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Hiura as applied to claim1 above, and further in view of Jin et el (USPN 6,283,812). Ajayan does not provide for the directional growing of the nanotubes on a support. However, Jin, in order to provide an array of nanotubes which contains a high directional density and thus efficient field emission properties, teaches a means of growing an aligned carbon nanotube ensemble by methods including CVD, arc discharge, and laser ablation. It thus would have been obvious to one of ordinary skill at the time of invention to grow nanotubes under a directional control in the process of Ajayan.

Regarding claims 18-19, Ajayan teaches the use of etching the nanotubes under a reactive gas as a method of opening the tubes. Jin teaches an extension of this process, whereby the tubes are etched with oxygen plasma (column 5, lines 24-28). It thus would have been obvious to one of ordinary still at the time of invention to implement the use of oxygen plasma as the media with which the nanotubes are etched.

Regarding claim 35 and 52, Ajayan teaches that the nanotube is available as its structural completeness for a device possessing a high mobility of electrons (column 4, lines 31-35). Jin teaches that this device may be put to use as the cathode of various articles, including microwave amplifiers and flat panel field emission displays. Cathodes containing nanotube emitters exhibit all of the properties advantageous to electron emission (column 9, lines 38-57). Thus it would

have been obvious to one of ordinary skill at the time of invention to put the nanotube products of Ajayan to use in the devices disclosed by Jin.

Claims 5 and 36-38 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Hiura as applied to claim 1 above, and further in view of Tanaka et al (USPN 5,951,832). Ajayan's process provides for the growing, opening, filling, and closing of carbon nanotubules, it does not provide for the same process to be applied to giant fullerenes, such as onions. Tanaka, however, teaches a process whereby an ultrafine particle is enclosed by a fullerene using an electron beam to drive the particle into the hollow center. Because this process has the same step sequence as that of Ajayan, it would have been obvious to one of ordinary skill to replace the nanotube of Ajayan with its close relative, the giant fullerene.

Regarding claims 36-37, if a stoichiometry of at least 60 carbon atoms relative to each atom of foreign species is assumed, Tanaka teaches the encapsulation of an ultrafine particle inside a giant fullerene. Because the giant fullerene is made up of concentric fullerene structures, it is apparent that the above stoichiometry is achieved.

Claim 6 is rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Hiura as applied to claim 1 above, and further in view of Zettl et al (USPN 6,057,637). Ajayan's process, as stated, only provides for carbon nanotubules. It does not take into account the derivatives of the pure carbon tubes. Zettl, however, in order to take advantage of their electrical properties such as field-emission characteristics, uses a carbon nanotube derivative, specifically BxCyNz nanotubes. These tubes contain varying amounts of boron and nitrogen on their side walls, yet are capped in the same manner as pure carbon nanotubes. Because the process of

Ajayan deals only with this capped portion, it would have been obvious to one of ordinary skill at the time of invention to perform the process of Ajayan on the nanotube derivatives of Zettl.

Claims 7-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Hiura as applied to claim 1 above, and further in view of Homyonfer et al. (USPN 6,217,843). Ajayan, as stated, does not provide for carbon nanotube derivatives. Homyonfer, however, teaches the intercalation of inorganic fullerene-like structures, such as nested fullerenes and nanotubes, with various metal atoms. These inorganic fullerene-like structures may take the form of MX_2 where M = Mo, W and S = S, Se. (column 1, lines 35-41 and column 2, lines 4-5). It thus would have been obvious to one of ordinary skill at the time of invention to include these structures in the process of Ajayan.

Claims 9 and 16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Hiura as applied to claim 1 above, and further in view of Gao et al ("Electrochemical intercalation of single-walled carbon nanotubes with lithium"). Hiura teaches a purification stage which provides that the amorphous carbon and nanoparticles are removed from the carbon nanotubes, however, he applies a process of acid reflux and filtration. Gao et al, in order to achieve the same result, purify the nanotubes by filtering the impurity phases through a membrane while keeping the nanotubes in suspension using a high-power ultrasonic horn. It thus would have been obvious to one of ordinary skill at the time of invention to substitute the purification process of Gao et al. in place of that of Hiura.

Regarding claim 16, the method of opening the nanotubes, as disclosed by Ajayan, is that of etching with a gaseous reactant. Gao et al, however, teach that mechanical ball-milling

increases defect density and reduces the length of SWNTs by fracturing the graphite layers. They disclose that the ball-milling may facilitate ion diffusion into the nanotubes. It is known in the art that cutting carbon nanotubes does, indeed, lead to tubes with open ends. It thus would have been obvious to one of ordinary skill at the time of invention to replace the etching process of Ajayan with the ball-milling process of Gao et al. in order to cut the tubes, leaving open ends.

Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Hiura as applied to claim 1 above, and further in view of Ebbesen et al. (USPN 5,641,466).

Whereby Hiura teaches the process of acid reflux followed by filtration for the purification of nanotubes, Ebbesen teaches that hydrogen peroxide is a useful purification agent. Therefore, it would have been obvious to one of ordinary skill at the time of invention to use the hydrogen peroxide of Ebbesen in the purification process of Hiura. Furthermore, the use of between 1-40% volume of hydrogen peroxide is viewed as using an optimum range, which is obvious as held by In re Boesch (205 USPQ 215).

Claim 14 is rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Hiura as applied to claim 1 above, and further in view of Ebbesen et al (USPN 5,641,466) and Resasco et al (USPN 6,413,487). The purification step of Hiura comprises refluxing the nanotubes in acid followed by filtering; it does, however, make note of extinguishing amorphous carbon and nanoparticles by an oxidation reaction. It does not give a specific temperature range within which this oxidation may occur. Ebbesen, teaches the purification of nanotubes by heating to a temperature of between 600 C and 1000 C in an oxidizing atmosphere (column 1, lines 41-50). Resasco, on the other hand, teaches the burning off of amorphous carbon under treatment with a

heated combustion gas containing oxygen. Resasco's oxidative purification takes place under temperatures of about 300 C (column 11, lines 32-55). Therefore, it is seen that oxidative purification can take place at temperatures as low as 300 C and as high as 1000 C. Thus, it would have been obvious to one of ordinary skill at the time of invention to heat the nanotubes, in an oxidizing environment, to a temperature within the range of 300-600 C.

Claims 15, 31-32, and 34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Hiura as applied to claim 1 above, and further in view of Liu et al. ("Fullerene Pipes"). The carbon nanotubes are opened by Ajayan using the process of etching by a reactive gas. Another means by which to open the ends of carbon nanotubes is taught by Liu et al. In this method, prolonged sonication of nanotubes in a mixture of nitric and sulfuric acids attacks the tubes, cutting the tubes and leaving open ends. It therefore would have been obvious to one of ordinary skill at the time of invention to replace the etching of Ajayan with the sonication of the purified tubes in acid process of Liu et al.

Regarding claims 31-32, Ajayan teaches any method of closing the filled nanotubes known in the art. A layer attached to the open end of the filled nanotubes was formed by Liu et al. This method includes converting the terminal groups of the open-ended nanotubes, followed by linkage of these groups to a solvent. These ends can further be bound to various other particles. It is taught that attachment of such strategically designed binding groups may be very useful in directing assembly of fullerene tubes into molecular devices. Therefore, it would have been obvious to one of ordinary skill at the time of invention to link the filled nanotubes to a passivation layer in order to control the binding properties of the nanotubes.

Regarding claim 34, Ajayan does not teach a washing step after any of the stages which follow purification. Hiura, however, does teach the necessity of clean and pure tubes in order to achieve desired properties. Liu et al disclose a method of further washing the nanotubes, in order to ensure that the cut nanotube pieces were molecularly perfect and chemically clean. It would have been obvious to one of ordinary skill at the time of invention to apply a further washing step to the already opened and/or filled tubes in order to ensure their purity and cleanliness.

Claim 17 is rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Hiura as applied to claim 1 above and Liu et al. ("Fullerene Pipes") as applied to claim 15 above, and further in view of Jin et al. (USPN 6,283,812). There are numerous methods of opening carbon nanotubes. Liu et al. teach a method whereas the tubes are sonicated in an acid medium, thus cutting the tubes and leaving open ends. Jin teaches a method whereby a high energy beam, such as an ion beam, is used to truncate an ensemble of nanotubes, thus leaving open-ended tubes (column 5, lines 21-28). It therefore would have been obvious to one of ordinary sill at the time of invention to apply both of these processes in order to ensure truncation and subsequent opening of a higher percentage of the tubes.

Claims 22-25 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Hiura as applied to claim 1 above, and further in view of Green et al (USPN 6,090,363). Ajayan discloses that it would be useful to fill the carbon nanotubes with various metals, superconductors, magnetic materials, organic molecules, gases, and alkali metals. Green takes this concept one step further by teaching that it would be useful to include metals or alloys in elemental form, including Mg, Ca, Sr, Ba, Sc, Y, Fe, Co, Ni, and Cu (column 2, lines 6-20). It is

further disclosed that the metals may be in combined form, that halogens such as F, Cl, and Br are useful materials, and additionally that the deposited material may be converted to the desired physical or chemical form after the filling process (column 2, lines 51-54). Therefore, it would have been obvious to one of ordinary skill at the time of invention to use halogen mixtures or metal halides as the deposited material.

Claims 29-30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Hiura as applied to claim 1 above, and further in view of Moskovits et al. (USPN 6,129,901). According to Ajayan, the opened nanotubes are filled by evaporation of the foreign species or gas transport of the foreign species. Another method is disclosed by Moskovits, whereby the open-ended tubes are filled by a reaction containing the foreign deposits and the nanotube material. He specifically discloses the use of Ni (column 4, lines 5-15), yet also teaches that numerous other metals may be deposited into the nanotubes, once formed. It thus would have been obvious to one of ordinary skill at the time of invention to fill the tubes by reaction of chemicals containing the foreign species and the purified tubes.

Regarding claim 30, it is further taught by Moskovits that "it will also be understood by those skilled in the art that the nanotubes may be filled with the metals by electrochemical deposition" (column 4, lines 48-50). It thus would have been obvious to one of ordinary skill to replace the filling mechanism of Ajayan with the electrochemical process of Moskovits.

Claims 39, 40, 42, and 43 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Hiura as applied to claim 1 above and further in view of Nakamoto et al (USPN 6,417,606).

Nakamoto teaches a carbon nanotube with a workfunction below 4.0 eV (column 5, lines 62-64). While this nanotube is not necessarily produced by the method of claim 1, the claim is considered as a product of process claim, whereby nothing that distinguishes the claimed product from the carbon nanotube of Nakamoto is obvious. Furthermore, Ajayan teaches that his metal intercalated nanotubes are useful for high electron mobility applications. It thus would be obvious to one of ordinary skill at the time of invention to use the process Ajayan and Hiura, to create the low workfunction nanotubes of Nakamoto.

Claims 47-48 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Hiura as applied to claim 1 above, and further in view of Lee et al. ("Conductivity enhancement in single-walled carbon nanotube bundles doped with K and Br"). Lee et al. teach that single-walled nanotubes are predicted to be intrinsically metallic. They further disclose that either elecron or hole doping (specifically doping with Br_2 or K) accompanies reductive or oxidative intercalation with enhanced metallic behavior in either case owing to increased carrier density. Therefore, in addition to single-walled nanotubes already exerting metallic behavior, it is obvious to one of ordinary skill in the art at the time of invention that the materials produced by filling the nanotubes, especially when filling with a metallic substance, will result increase this metallic behavior.

Claim 49 is rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan et al. (USPN 5,457,343) in view of Green et al (USPN 6,090,363). Ajayan teaches a method of opening carbon nanotubes, filling them with an alkali metal or other such useful substance, and closing the openings. Green teaches that among these useful substances of Ajayan may be

included alkali metals, alkaline earth metals, and alloys and combinations thereof. It thus would have been obvious to one of ordinary skill at the time of invention to include the alkaline earth metals taught by Green in the process of Ajayan

Claim 50 is rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Green as applied to claim 49 above, and further in view of Gao et al ("Electrochemical intercalation of single-walled carbon nanotubes with lithium"). While Ajayan teaches a method of etching to open the carbon nanotubes, Green teaches that the same can be accomplished by treating capped nanotubes with a liquid comprising an oxidizing agent. The example he uses is nitric acid, as it attacks the end-caps very specifically (column 2, lines 54-59). Additionally, Gao et al. teach that mechanical ball-milling increases defect density and reduces the length of SWNTs by fracturing the graphite layers. They disclose that the ball-milling may facilitate ion diffusion into the nanotubes. It is known in the art that cutting carbon nanotubes does, indeed, lead to tubes with open ends. It thus would have been obvious to one of ordinary skill at the time of invention to replace the etching process of Ajayan with either the oxidation process of Green or the ball-milling process of Gao et al. in order to create open ends.

Claim 51 rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan, Green, and Gao as applied to claim 50 above, and further in view of Liu et al ("Fullerene Pipes"). Ajayan teaches any method of closing the filled nanotubes known in the art. A layer attached to the open end of the filled nanotubes was formed by Liu et al. This method includes converting the terminal groups of the open-ended nanotubes, followed by linkage of these groups to a solvent. These ends can further be bound to various other particles. It is taught that attachment of such

strategically designed binding groups may be very useful in directing assembly of fullerene tubes into molecular devices. Therefore, it would have been obvious to one of ordinary skill at the time of invention to link the filled nanotubes to a passivation layer in order to control the binding properties of the nanotubes by using a solvent.

Claim 53-59, and 62 rejected under 35 U.S.C. 103(a) as being unpatentable over Jin et al. (USPN 6,283,812) in view of Abayani et al. (USPN 5,457,343) an further in view of Jin et al. (USPN 5,977,697). Jin teaches a process beginning with the production of an aligned nanotube ensemble on a support surface. Regarding claim 54, Jin discloses that the aligned carbon nanotubes may be grown by methods including chemical vapor deposition (column 4, lines 60-65). He discloses next that the aligned carbon nanotubes are substantially encapsulated in a solid matrix, or insulating layer (column 7, lines 15-35). Regarding claim 55, he discloses that polymer encapsulates are useful. Jin also teaches opening of the tubes by truncating them. Regarding claims 56-57, this opening may be performed by etching with ion or plasma beams (column 5, 22-27). Regarding claim 58, it is also seen that Jin discloses a process of opening the nanotubes whereby a portion of the encapsulating matrix is removed (Figure 4). He does not, however, provide a process for filling or closing these tubes, although he notes the process (column 5, lines 60-62). Ajayan, however, discloses a process for filling and closing carbon nanotubes which were previously opened. Regarding claim 59, Ajayan teaches a method of filling that involves the evaporation of the foreign species into the open end of the nanotube (column 3, lines 60-67). Due to the increased electron emission properties of filled nanotubes, it would be obvious to include these stages in the process of Jin.

Furthermore, Jin et al, in USPN 5,977,697, teach a method of activating diamond particles found on electron emission devices by exposing them to a hydrogen plasma (column 5, lines 39-41). It is disclosed that this process cleans the surface by removing carbonaceous and oxygen or nitrogen related contaminants, removes graphite or amorphous carbon from the surface, and improves contacts between the particles and the substrate which are important in sustaining a stable electron emission process (column 5, line 60 to column 6, line 5). It is known in the art that diamond particles may be exchanged for carbon nanotubes for use as electron emitters. It is also seen that this process of removing contaminants from the surface of the diamond, etc. is one which is useful for improving the properties of carbon nanotubes as well. Thus, it would be obvious to include the step of activating the filled nanotubes using a hydrogen plasma treatment in the process of Jin.

Claim 60 is rejected under 35 U.S.C. 103(a) as being unpatentable over Jin, Ajayan, and Jin as applied to claim 53 above, and further in view of Moskovits et al. (USPN 6,129,901). While Ajayan discloses a means of filling the tubes by evaporation of the foreign species, Moskovits notes that open-ended nanotubes may be filled with metals by electrochemical deposition (column 4, lines 48-50). It therefore would have been obvious to one of ordinary skill at the time of invention to replace the evaporation procedure of Ajayan with the electrochemical process of Moskovits.

Claim 61 is rejected under 35 U.S.C. 103(a) as being unpatentable over Jin, Ajayan, and JIn as applied to claim 53 above, and further in view of Liu et al. Ajayan teaches any method of closing the filled nanotubes known in the art. A layer attached to the open end of the filled

nanotubes was formed by Liu et al. This method includes converting the terminal groups of the open-ended nanotubes, followed by linkage of these groups to a solvent. These ends can further be bound to various other particles. It is taught that attachment of such strategically designed binding groups may be very useful in directing assembly of fullerene tubes into molecular devices. Therefore, it would have been obvious to one of ordinary skill at the time of invention to link the filled nanotubes to a passivation layer in order to control the binding properties of the nanotubes.

Claims 63-64 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ajayan and Green as applied to claim 49 above, and further in view of Jin et al (USPN 6,283,812). Jin teaches the use of nanotubes in electron emission devices including microwave amplifiers and flat panel displays. It is further noted that any nanotube product with the enhanced properties of claim 49 would be useful in any field-emitting device which is well known in the art. It would have been obvious to one of ordinary skill at the time of invention to use the nanotubes of claim 49 in the devices of Jin.

Allowable Subject Matter

Claims 13, 41, and 44-46 would be allowable if rewritten to overcome the rejection(s) under 35 U.S.C. 112, second paragraph, set forth in this Office action and to include all of the limitations of the base claim and any intervening claims.

Conclusion

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure: USPN 6,383,923 to Brown et al.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Peter J Lish whose telephone number is 703-308-1772. The examiner can normally be reached on 9:00-6:00 Monday through Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stanley Silverman can be reached on 703-308-3837. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9310 for regular communications and 703-305-9311 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0661.

PL
October 21, 2002

STUART L. HENDRICKSON
PRIMARY EXAMINER